Distribution of vegetation on Maya ruins and its relationship to ancient land-use at Lamanai, Belize*

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COMPENDIO

Se realizó un análisis cuantitativo de la vegetación forestal en el asentamiento antiguo maya de Lamanai (circa *300AC- 1640 AD) para determinar la relación entre la vegetación existente y las ruinas mayores y menores Se determinaron cinco asociaciones Shore Line, Cohune Ridge, High Bush, Bajo, y Ruin La asociación Ruin, dominada por* Brosimum alicastrum, Protium copal, Talicia oliviformis *y* Pimenta dioica, *era única Los actuales descendientes de los mayas consideran la presencia de Cohune como un indicador de buena tierra para sus milpas Los análisis de suelos indican que las asociaciones Cohune Ridge y Bajo podrían ser apropiadas para la agricultura. Una muestra de taladro del sedimento de un lago cercano reveló que las quemas eran comunes en tiempos lejanos Dos capas (95 y 280 cm) contenían grandes cantidades de fragmentos vegetales carbonizados.*

Introduction

IN 1974 the Royal Ontario Museum commenced excavation at Lamanai, a Maya settlement considered to have been in use for 1900 years or more (circa 300 BC - AD 1640) and up to the present day on a limited scale. As a background environmental report to complement the archaeological mapping, a vegetation study was initiated in 1976 In addition it was seen as a means of identifying areas of probable domestic occupancy not revealed by surface features. The aim of the vegetation analysis was to identify the dominant communities, and to determine what relationship, if any, there was between the extant vegetation and the major and minor ruins being excavated

Several recent papers (8, 13) on Maya sites in Central America have suggested that an efficient land-use program would have been necessary to support the large settlement population Regardless of whether sites were established on natural waterways or not, water would have been a necessity of life The pattern of mean annual rainfall for the Maya area of Belize results in a fairly well-marked dry season of 3-4 months Because food storage would have been difficult, it no impossible, food production would have had to be continuous In both upland and lowland regions abandoned terraces and irrigation canals have been identified in northern Belize, Dept. of Peten, Guatemala, Campeche and Quintana Roo States, México

Ower (14) holds that the extent of Maya settlement in Belize coincided strictly with the extent of calcareous soils. He further suggests that the lands surrounding known centres of occupancy have at some remote time been under cultivation and that they are now been occupied by secondary and not primary forest. Lundell (10) and Bartlett (2) have observed a number of the same tree species present on every Maya ruin of the southern culture they had visited They further sugget such trees were cultivated for shade and food

The fact that this region of lowland Central America supported a large population in the past means that any information concerning ancient land-use is of practical importance. The existence today of a closed forest system would imply the region is not unproductive and therefore capable of producing agricultural crops again if present day environmental conditions are understood and wise agricultural methods followed

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Study area

The northern part of Belize is physiographically a part of the Yucatan Peninsula and is a heavily karsted limestone plateau of Cretaceous age. Lamanai is located in the north east sector of this plateau on the west shore of the New River Lagoon at its entry into the New River (Figure 1). Both the river and the lagoon are controlled at this point by a small fault scarp with Lamanai being on the dip slope. The lagoon is maintained largely by groundwater flow and has a relatively high sediment and mineral load. Erosion of the limestone scarp results in a high $CaCO_3$ deposition.

The site is underlain by a creamy pink, moderately hard, amorphous limestone. Soils in the area are those of the Yaxa group (20) being grey-brown clays. Yaxa shows the development of: a normal soil type on nearly level topography, a shallow gravelly soil on undulating land, a deep melanized soil under Cohune forest, and a mottled clay in bajos (areas of impeded drainage).

The vegetation is classified according to Wright (20) as, broadleaf decidous forest and is included in the lowland, dry tropical zone. According to Beard's (3) classification of tropical forest, Lamanai falls within the zone of semi-evergreen seasonal forest. The forests have been almost completely exploited for their mahogany and even to the present day the area supports shifting agriculture.

The area receives approximately 1480 mm of rainfall annually, based on the ten year average for Orange Walk twenty miles to the northeast. A distinct dry season occurs from January to May. Temperatures in Belize range from 18 - 35°C with a mean annual temperature of 27°C. One Fuess hygrothermograph was maintained at the site from late May to mid July, during the latter part of the dry season and beginning of the wet season. Mean temperature for the period was 28°C. Relative humidity was high, with 100% recorded every day but two. Precipitation was measured using a standard rain gauge. Total received was 580 mm. During the 56 day period there were 24 days without rain resulting in an average of 180 mm/day for the 32 days with rain.

Methods

Four community types were initially identified from air photographs of the site and surrounding forest, and verified in the field. A fifth type, Pine Ridge, to the north east of the site was also included in the analysis.

For archeological purposes the site was divided into 500 m² quadrats covering an area of 6 km². Lines were cleared by hand, surveyed and staked. Survey lines were used as starting points for all transects except those on the ruins and Pine Ridge. Line transects of contiguous 10×10 m² quadrats were placed in representative examples of identifiable community types. Vegetation on the ruins (tops and sides) was sampled in a similar manner.

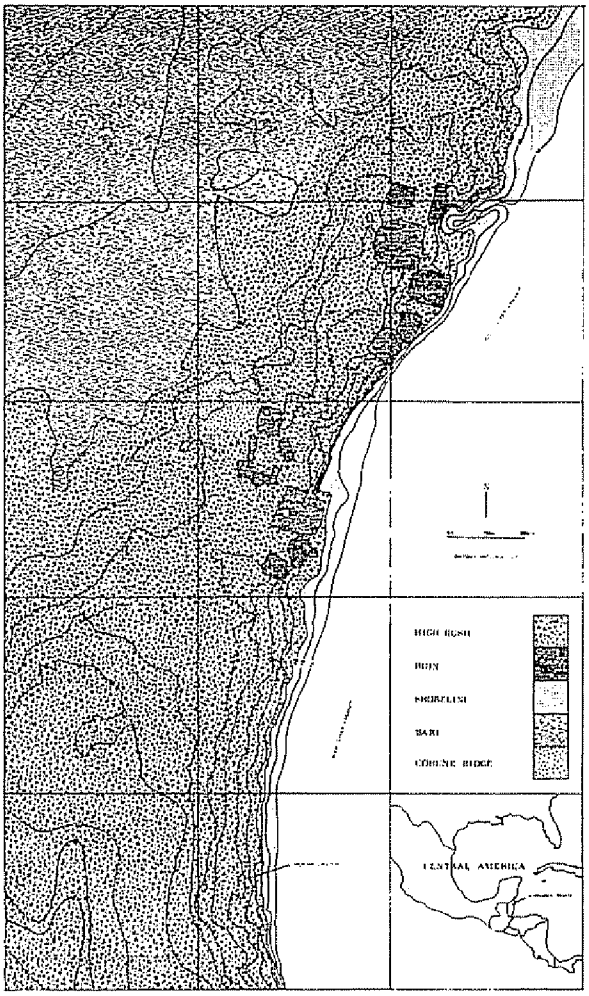

Fig. 1.—*Vegetation of the Maya ruins at Lamanai, Belize*

Within each quadrat the presence of all tree species and their basal area at breast height and all sapling (dbh < 12sq in) were recorded. Ground vegetation was sampled using five 1 m² quadrats that were placed at the same points in each 10×10 m² quadrat. Representative samples of all species were collected for later positive identification.

Quantitative data on tree composition were summarized for each transect. Relative frequency, relative density and relative dominance were determined and their values for each species were summed to provide importance values, which for all trees in the transect totalled 300. Relative frequency and relative density were determined and summed for all sapling and seedlings. True density of trees, basal area and saplings per hectare were also calculated.

Transect data analyses have been accomplished using the calculation of a correlation coefficient to determine the relationship between transects (communities). All species, including those occurring in only one transect, were used. Such rare species can contribute information about overall variation if the vegetation is markedly heterogeneous (1).

Transect data were ordinated by principal component analysis (Statistical Package for Social Sciences (SPSS), Carleton University). Variables were transformed into a new set of component variables that were orthogonal (uncorrelated) to each other. The first axis lies through the spatial cluster of points (transects) in such a direction that it covers the maximum amount of variation within a cluster. Subsequent axes are similarly oriented with respect to decreasing residual variation.

Five soil samples were taken for chemical and phisical analysis. Soil moisture content was determined from samples of known weight that were oven dried (60°C for 24 hr) and reweighed. Percent coarse material was calculated from the weight of soil from a known quantity that would not pass through a 2 mm sieve. Textural analysis was completed using the hydrometer technique (4). Total N was determined by micro-Kjeldahl technique; available phosphorus colourmetrically and exchangeable cations (Ca, Mg, K, Na) by atomic absorption spectrophotometer. Cation exchange capacity (CEC) was determined using techniques described by Jackson (9).

Plant identifications were verified by the Missouri Botanical Garden, St. Lous, Missouri and a representative of every species deposited in their Herbarium.

Results and Discussion

Presented in Table 1 are the importance values for the 100 trees present in one or more of the transects sampled. The high diversity and low species predominance for the Lamanai area is typical for the tropics (16). In spite of the general low representation of species within any one quadrat, due to species richness, local concentrations of species do occur.

Only five species were present in more than fifty percent of the transects sampled while approximately forty percent were present in only one quadrat. Except for the Pine Ridge transects, 21 and 22, the importance values of the dominant never exceeded 155 and were as low as 38.

The ordination of the 22 transects (Figure 2) reveals six associations, Shore Line, Cohune Ridge, Bajo, High Bush, Ruin and Pine Ridge, with a directional change in the vegetational composition from natural forest to ruin forest. The natural forest shows a strong progression toward the origins of axis 1 while the ruin vegetation shows a divergent trend along axis 2. The occurrence of the Pine Ridge with the Shoreline, Cohune Ridge and Bajo associations is recognized as an anomaly. With additional stands sampled and by a three dimensional ordination model it is expected that the four associations will be more clearly identified.

Shoreline

The Shoreline association which is subjected to seasonal flooding is dominated by *Bucida buceras*. Actual

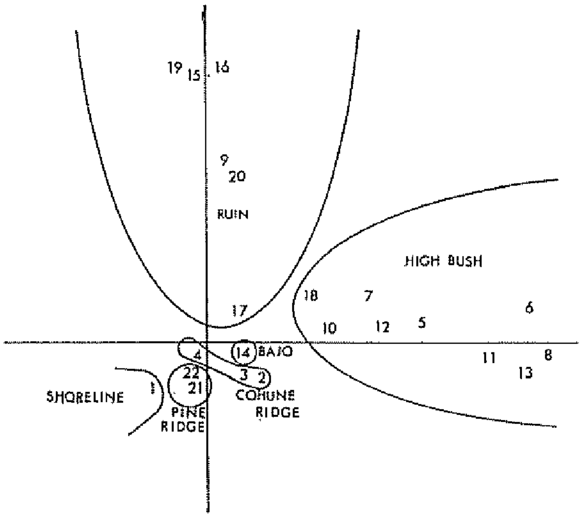

Fig. 2.—*Ordination of the 22 transects showing the six plant associations.*

width of the association would appear to be related to the level of high water at the end of the rainy season. Individuals of *B. buceras* often project over the water even at the lowest level. Fallen trees give rise to many new shoots which can reach tree size. *Ficus* spp are not common; however, when present they are generally large. Epiphytes and vines cover the trees so that from the water the shoreline appears to be an impenetrable mass of vegetation. However, within the community the ground is relatively clean due to the annual flooding and deposition of sediments.

Another common shoreline tree is *Pachira aquatica*. The large fruits contain seeds which can germinate when floating and quickly establish in the shoreline mud.

Adjacent to the Shoreline association are pure stands of *Bactris major*, near the limit of hight water. In the analysis *Bactris* which did not reach tree size was included in the shrub layer of the shoreline association.

Cohune Ridge

The Cohune Ridge association is not as extensive in areal coverage toward the north end of the New River Lagoon as it is at the south end. A number of stands of pure *Orbignya cohune* are present in the Lamanai area. In such cases the trees are tall with wide spreading crowns. Canopy is almost completely closed resulting in a very sparse ground flora with *Orbignya* seedlings and saplings as virtually the only ones able to establish and survive. Within such stands the understory is open and has a cathedral-like quality. While the two stands sampled were dominated by *O. cohune* there were several other species that attained canopy height. They include: *Swietenia macrophylla*, *Spondias mombin*, *Guazuma ulmifolia* and *Enterolobium cyclocarpum*.

Table 1 —Importance values for all trees in the twenty-two stands sampled

Species	Stands 1	2	3	4	7	5	6	13	8	10	18	11	12	14	9	17	15	16	19	20	22	21	Stand of Occurrence	Stand Dominants
Andira inermis	5																						1	
Borreira verticillata	29																						1	
Calophyllum brasiliense	30																						1	
Pachira aquatica	66																						1	
Bucida buceras	110	27				6																	3	1
Ficus sp	33	3											42		18								4	1
Acacia collinsii	5	2						7		8			6			2	4						7	
Coccoloba belizensis	10	48			19		10		22	9		42	13	6		4		4					11	
Nectandra sp.	5	7		6	51		14		50	6	9	12	7					2					11	1
Bursera simaruba	6	2					4	14		2		5				2	5	27	9	26			11	
Crataeva tapia		7				3				2				7									4	
Leucaena guatemalensis		5											7					3					3	
Hirtalla paniculata		2									2					2							3	
Aspidosperma megalocarpon		5													3			2					3	
Guettarda combsii		10													7								2	
Swietenia macrophylla		51	31								17												3	1
Metopium brownei		2																		5			2	
Simarouba glauca		13			8		6		9	5			13			2							7	
Casearia sp.		20	8										4	35									4	
Trophis racemosa		6			21			15	5		2		18			2							5	
Erythroxylon affine		6			25		2					9											6	
Parmentiera aculeata		2			4	11	2	18	19		4					2							8	
Guettarda elliptica		2	11		14			4			2		4	11		2							8	
Guazuma ulmifolia			7	21			44	65	110	88	21	24	68	25		9	8						12	5
Spondias mombin				15	32	15	17	26	26	20	26	23	25	42	33	52	9	40		12			16	1
Crysophila argentea		4				25	2	11		38	35	7	15				34	9	2	5			12	1
Simira salvadorensis		14		22		12	2			17	14	15	3			9	13	5	12	9			13	
Guatteria amplifolia		2					8			3	3					4		24	29				7	
Unidentifiable (077)		4									2	17	6				2	8	27	12			8	
Sabal mauritiiformis		9		7			2				2			43	10		16	11	14				9	
Pimenta dioica		4				6				12	2		7		9		17	17	7				9	
Pouteria durlandii		24		6	4				4	2			4		17	2	6	9					10	
Brosimum alicastrum		4			19						9				21	6	79	37	49	28			9	2
Liana			11					7															2	
Pouteria amygdalina			10													2	6						2	
Swartzia cubensis			7			4					2				5		4						5	
Orbignya cohune			130	155			4			5	33		9			16	3						8	2
Enterolobium cyclocarpum				24		11	11	24		10	4												5	
Cupania belizensis				7							5					2							3	
Ehretia tinifolia				14							4	5	3			2							5	
Unidentifiable (075)				8															6	5			3	
Cordia sp. (?)				4									6										2	

Table 1.—(continuation).

Species	1	2	3	4	7	5	6	13	8	10	18	11	12	14	9	17	15	16	19	20	22	21	Stand of Occurrence	Stand Dominants
Trichilia hirta					29	10	22	32	14	2		5	10										8	
Guarea sp.					3		2				24					53							4	
Sapindus saponaria					13			3	4				8	7			14						5	
Lonchocarpus guatemalensis					4		11	7	16	8	4	8	9	8		4	4						9	
Chlorophora tinctoria					5		7	4								3	2	3					6	
Trichilia havanensis					5	14	3	15	5	8	5		3			5	2		8	5			12	
Pithecolobium sp.					4		4	7						8				6					5	
Dalechampia scandens						4																	1	
Alseis yucatanensis						10																	1	
Cassia grandis						12																	1	
Ceiba pentandra						5			4			13	3										4	
Lonchocarpus castilloi						7							12	12	4								4	
Vitex gaumeri						4	4						3		10								4	
Sebastiania pavoniana						6	9		5					6	9			3					6	
Stemmadenia donnell-smithii						37	21		6	28	53	36			39	55	3		25				10	
Cedrela mexicana						13		8		22					4	7	3	5					7	2
Guarea glabra						12				12				5	10	6	4	6					7	
Castilla elastica						20	12			11	2		15		35	8	25	41	26				10	1
Dendropanax arboreus							15	4			4		3			2							5	
Dipholis durifolia							7									6							2	
Talisia oliviformis							10		4		6		2		60	2	16	15	31				9	1
Heisteria sp.							3							37			31		19		6	115	5	1
Citrus sp.										2													1	
Pouteria mammosa										12													1	
Pouteria campechiana										3	4					4	9			7			5	
Ficus aff. lapathifolia											9				3	3	12	17	11				6	
Callicarpa acuminata													5										1	
Croton schiedeanus														5									1	
Sweetia panamensis														11									1	
Gymanthes lucida														31			3	10					3	
Cracca sp.															4								1	
Achras zapota																	6						1	
Sapindaceae																	6						1	
Cecropia sp.																		3		13			2	
Morus sp.																			14	5			2	
Allophylus campotostachys																			11	84			2	
Curtella americana																					45		1	
Acoelorrahphe wrightii																					255		1	1
Pinus caribaea																						300	1	1
Total Species	10	30	12	14	20	23	29	17	18	26	28	16	29	17	21	32	29	25	19	10	2	1		
Nº trees/hectare	700	780	570	420	620	600	590	750	400	975	600	960	900	560	750	610	755	790	640	970	140	20		

Unknown species leaves and/or flowers unobtainable (species Nº/Stand Nº/IV)

501 2(2) 503 3(13) 505 4(12) 515 4(12) 410 7(8) 507 8(5) 509 12(3) 511 15(2) 513 19(8) 089 14(6)

502 3(19) 504 3(7) 515 4(12) 411 7(7) 506 7(8) 508 8(5) 510 14(10) 512 15(2) 084 14(6)

Wherever cohune dominates, a large amount of litter is produced, especially around the bases of individual trunks. During the rainy season snakes are abundant in the raised, drier mounds of litter. Drainage within such stands is moderate to good, however the fertility reserve and moisture retaining capacity give this soil great value (20)

Local farmers view the occurrence of the Cohune as an indication of good land for their milpa operations. To the ancient Maya it was probably a similar indicator as well as source of oil for cooking and lighting

Ruin

Lamanai is dominated by seven major structures or pyramids, the tallest being 26 meters. A large number of lesser, but nevertheless substantial structures are also present and together occupy an area of approximately 500 m² and constitute the center of the site. Within the surrounding forest (3 km²) are many small structures, no more than several meters high.

Architectural preservation is generally poor and the pyramids and lesser structures are covered with limestone rubble. At the base of each pyramid is a large amount of unconsolidated rubble.

The vegetation on the ruins major forms a characteristic association that is readily distinguished from the surrounding forest. *Brosimum alicastrum, Protium copal, Talisia oliviformis* and *Pimenta dioica* are common trees and *Diopholis salicifolia* and *Guatteria amplifolia* common saplings. Their occurrence in the surrounding forest is also an indicator of small structures many of which are covered with a thick layer of litter. Epiphytic aroids, bromeliads and cacti are common on the ruins, but there are considerably fewer lianas than in the surrounding forest.

Bartlett (2) recognized a separate ruin association, *Higueral de las Ruinas,* in British Honduras and the Peten. However, other than a number of epiphytes, no trees present at Lamanai were included in Bartlett's species list. The occurrence of *Brosimum alicastrum* on every ruin Maya was noted by Lundell (11) and was thought to have been cultivated for fruit and shade.

As expected soil development on the ruins is minimal and surface roots are everywhere evident. The litter and humus horizons combined rarely exceed 15 cm in thickness and overlie a limestone rock base (pyramid). Roots have penetrated into the structures resulting in their external destruction. During the rainy season the soils tend to dry very rapidly between downpours. The ruin association is particularly attractive decause it is open (sparse underbush), dry and cool since it is raised above the surrounding jungle

Several very large dead *Achras zapota* were present on the summits of two pyramids. Evidence of chicle harvesting was observed.

High Bush

High Bush encompases all forest that is not Shoreline, Cohune Ridge, Ruin, or Bajo association. The association is very diverse, with no one species attaining an importance value greater than 110. A number of species occur frequently. They include; *Guazuma ulmifolia, Spondias mombin, Stemmadenia donnell-smithii, Nectandra* sp, *Coccoloba belizensis* and *Ficus* spp

The upper canopy is not always closed or even, and it is rarely higher than 25 m. However, occasional trees are higher such as *Enterolobium cyclocarpum,* one which was estimated to be 36 m high with a circunference of 6.1 m. The ground cover is abundant, well shaded but not impenetrable and includes many *Cryosophila argentea, Piper amalgo* and *Orbignya cohune* saplings. Lianas are also abundant.

With further study the High Bush could be divided into a number of discrete associations. Almost pure stands of tree *(Guazuma ulmifolia)* were observed in some areas.

The influence of topography should be noted. Near the lagoon the land is sloping and rocky and relatively dry, but level further inland and more moist. *Cedrela mexicana* is more common in the former area, *Swietenia macrophylla* in the latter. Another factor that must be taken into account is the effect of disturbance. Much of the area around the church and abandoned sugar mill (Figure 1) was pasture fifty years ago while other areas to the west of the lagoon may have remained relatively intact since the collapse of the Maya civilization. Recent logging operations by the Belize Estate and Produce Company and Loskot Brothers have culled the best of the mahogany, Santa Maria and Cedar in the area. The association does not resemble any of the assemblages considered by Wright (20) to occur in the areas. Centuries of selective cutting may have favoured *Spondias mombin, Guazuma ulmifolia* and *Stemmadenia donnell-smithii* which are not cut for lumber.

Bajo

To the northwest of the site is a large bajo or wooded swamp which is covered by water during the rainy season but dries out during the dry season. Bajo vegetation is distinct and can best be described as an impenetrable thicket where a machete is more important than a note book. The canopy is low rarely higher than 15 m although the occasional large tree *(Spondias mombin, Swietenia macrophylla* and *Sweetia panamensis)* does emerge over the general canopy level.

The thick underbush is characterized by spine or thorn covered species such as; *Bactris major, Crysophyla argentea* and *Pisonia aculeata* and *Aechmea magdelanae*. The latter species is a good indicator of bajo

A greater number of saplings and vines are present in the Bajo than any other association. The low number of species, 18, that attain tree size can probably be attributed to the dense underbush. The ground is in continuous shade, and competition for light and nutrients must be considerable. Trees would have to be shade tolerant for a number of years before they were able to emerge from the dense underbush.

Soil in the bajo sampled was classified as Yaxa mottled clay. A thin organic litter layer overlies a black clay, highly organic layer to a depth of 20 cm. The clay is plastic and slightly mottled. The limestone base of the area is reflected in the near neutral condition of the humus layer - pH 6.8. The highest percent moisture content of all the sites sampled was in the bajo - 31.6 and reflects the high water-retaining capabilities of the soil.

A great deal of controversy on the ancient use of the bajos by the Maya is to be found in the anthropological literature (6, 7, 8, 17). At present the bajos are used only for limited rice production by the local Maya farmers because of their flooded conditions during most of the year and their hard baked surface in the dry season. Infra-red air photography will be used in 1977 during the rainy season to determine the presence or absence of an irrigation system at Lamanai. Recent studies by Matheny (13) in Campeche, Mexico, have shown that such structures are detectable by such photography, and have placed a new emphasis on Maya agricultural practices.

Pine Ridge

The sparse vegetation of the savanna or pine ridge is in sharp contrast to the lush growth of the other associations. The transition from bajo or high bush to pine ridge can be quite abrupt and stems from a change in soils founded on a limestone base to ones formed on silicaceous material (5). Consequently pine ridge soils are sandy, slightly acidic and depauperate (Table 2). Water drains quickly from them and only xerophytic species survive. For the most part, the pine ridge is an open grass land, where sedges, members of the Cyperaceae, and many species of wild flowers form the ground cover. Pine is the dominant tree, but occurs at very low frequency (two trees per 1000 m² is typical). *Cresentia cujete, Curatella americana* and *Byrsonima crassifolia* are common species that reach tree size. These and several other species form a sparse shrub layer. In low areas or depressions, where water tends to collect in the wet season, the small pimenta palm, *Acoelorrhaphe wrightii,* forms pure stands. As in other areas of Belize (18, 19) the grasslands of the pine ridge at Lamanai are encouraged by the local people who annually burn the area, killing many of the smaller shrubs and tree seedlings. This practice is undertaken at the end of the dry season (May). It is thought to provide better grazing land for deer and brocket, which are hunted, as well as domestic cattle which are allowed to range freely in this area.

Soils

Chemical analyses of five soils (humus layer only) presented in Table 2 clearly indicate the intensity of biological circulation in the different associations. Percent organic matter is low, less than 18, in all samples. Plant debris is rapidly reduced and elements are taken

Table 2.—Summary of soil chemical and physical analyses for the A horizon at Lamanai, Belize.

	Cohune Ridge	Bajo	High Bush	Ruins	Pine Ridge
Soil moisture content % water of total wt	22.7	31.5	16.8	24.2	25.0
pH	7.2	6.8	6.9	6.6	6.05
Exchangeable Cations ppm (1 g/100 ml)					
Ca	145.0	90.0	245.0	240.0	55.0
Mg	6.0	8.0	4.0	6.5	10.0
Na	2.0	0.5	0.3	0.1	0.5
K	9.0	2.5	1.7	1.8	0.8
Mn	0.1	0.2	0.3	0.3	0.2
P (available)	1.25	0.14	1.25	0.26	0.08
Cation Exchange Capacity	125.0	90.0	210.0	210.0	7.0
% Nitrogen	0.23	0.28	0.115	0.275	0.086
% Organic Matter	15.05	17.4	9.46	13.79	3.56
Sand %	43	33	28	34	45
Silt %	15	11	30	34	18
Clay %	42	56	42	32	37

up again or lost to leaching. Ca and K predominate among the macronutrients. The neutral conditions of the soil is indicative of the limestone base that underlies the region

From an agricultural standpoint the Cohune Ridge and High Bush are the most favourable. The finer textures of these moderately drained soils carry more clay and therefore the cation exchange capacities are higher. The higher organic matter in the Bajo and lower cation values indicate the impeded drainage conditions and therefore a slower rate of decomposition. The almost continuous and therefore a slower rate of decomposition The almost continuous breakdown of organic matter and movement through the soil results in a high base saturation as indicated by the high pH values.

The Pine Ridge soils, being loamy sand, are low in collodial clays and deficient in humus. Agriculturally such soils have both low fertility and certain physical drawbacks.

Conclusions

The plant associations studied at Lamanai, while reflecting the drastic activities of the lumber companies, do not differ to any great extent from those that not have been exploited farther to the west. The Ruin association can be considered unique; however, natural limestone outcrops need to be studied to determine if they support a similar or different plant association.

There are a large number of economically important species in the area, although no groves or orchards were found. Such important species could have been cultivated by the ancient Maya. Our modern ethnobotanical study has identified thirty species that are used today and probably were used in the past.

Lundell (12) suggested that the Maya cleared and cultivated an ever increasing amount of land in the vicinity of their settlement: The effect that such practices had on changing the species composition, fertility and topography of the area is controversial (6).

Archeological evidence suggests that 6800 people could have been resident at Lamanai at any one time (Pendergast, personal communication). Recent excavations west of Orange Walk (20 miles N.E. of Lamanai) have exposed a ridged-field system of cultivation which may have been used by the people of Lamanai as well.

In recent years the Maya have been returning to the area with the result that milpas, in various stages of succession, are increasing in number. The success of the milperos is in part due to the general fertility of the land, which might be one reason why the ancient Maya originally established the site.

A three metre core taken from an almost closed lake system southwest of the site was taken for analysis and 14C dating in 1976. Initial analysis of the cores shows that between 95-100 and 260-300 cm a high percentage of carbonized plant fragments were deposited. The occurrence of such material indicates that burning was a common practice in ancient times. Corn pollen occurs throughout the core but not in any appreciable amount. Positive pollen determination has been difficult due to the lack of a good pollen reference collection of forest, wetland and agricultural species. In 1977 a reference collection will be made and more core taken. A more detailed pollen study and possible identification of an irrigation system should give information regarding ancient land-use practices that can be correlated with the distribution of extant vegetation both on the ruins and surrounding area of occupation.

The data presented above and those from future pollen and irrigation studies can be of value relative to an understanding of present day conditions and aspirations viz agricultural production. Palacio (15) concluded in his review of anthropology in Belize: "He (the researcher) should plan his study, not in the abstract atmosphere of university departaments, but in terms of the needs of the people of the location". If we can meld the knowledge of ancient land-use with that of present day needs wealthy countries will go a long way to making a positive contribution to the needs of the people in the Third World. It is hoped that the information presented and to be presented will be of value to the Ministry of Agriculture and Lands in Belize in light of their decision to open the area to organized settlement; and their desire to pursue a sedentary agricultural policy as opposed to the present slash and burn operation.

Summary

A quantitative analysis of forest vegetation at the ancient Maya settlement of Lamanai (ca 300BC - AD 1640) was undertaken to determine the relationship between extant vegetation and the major and minor ruins. Five associations were distinguished: Shore Line, Cohune Ridge, High Bush, Bajo and Ruin. The Ruin association, dominated by *Brosimum alicastrum, Protium copal, Talisia oliviformis* and *Pimenta dioica,* was unique. Present day Maya residents view the occurrence of Cohune as an indicator of good land for their milpa operations. Soil analyses indicate that the Cohune Ridge and Bajo associations would be suitable for agriculture. A sediment core taken from a nearby lake revealed that burning was common in ancient times. Two layers (95 and 280 cm) contained large amounts of carbonized plant fragments.

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Reseña de Libros

JEFFREY, CHARLES. Biological nomenclature. 2nd ed. London, Edward Arnold for The Systematic Association, 1977 72 p. £ 1,95 net

La primera edición de este libro contribuyó a destruir el mito de que la nomenclatura biológica, con todos sus intrincamientos, era del dominio privado de unos pocos especialistas iluminados. Mediante su enfoque directo y su estilo lúcido, el autor presentó las complejidades legalísticas de los varios Códigos de nomenclatura en una manera tal que los hizo fácilmente comprensibles y aplicables por biólogos de todos los niveles de experiencia, desde el estudiante al taxónomo profesional. Los códigos oficiales son documentos imponentes y difíciles de usar sin adiestramiento o guía especiales. Principalmente por estas razones, la Systematics Association auspició la producción de una guía sencilla de los principios de la nomenclatura y de las disposiciones de los varios códigos.

El primer capítulo que resume el contexto general de la sistemática, sigue siendo una de las exposiciones más claras del tema. El glosario-índice es también excelente. Entre estas dos partes están los demás capítulos, en los que se explica la nomenclatura, tratando simultáneamente todos los códigos en cada paso de la descripción de los principios y operación de la nomenclatura. Entre los códigos, hay que distinguir al botánico y el zoológico que se pueden considerar como que han alcanzado cierta estabilidad, sin que se esperen muchos cambios en el futuro. En cambio, el código bacteriológico ha tenido en 1975 una nueva edición radicalmente revisada y el código virológico tendrá que esperar bastante para su edición definitiva, ya que la naturaleza de los virus como seres independientes no encaja en las normas vigentes para definir un ente viviente, planta, bacteria o animal.

En esta edición, se han hecho las correcciones para incluir los cambios hechos en los códigos desde la publicación de la primera edición en 1973. Esto incluye, aparte de los importantes cambios para bacterias, los pequeños cambios en el código botánico en el Congreso Internacional de Leningrado, en 1975; algunos cambios en el código zoológico; y las nuevas guías para los nombres de cultivares publicados en 1974 (*Plant Varieties and Seeds Gazette* 109:1-3). Por último, se incluyen las reglas revisadas aceptadas de nomenclatura viral, publicadas en 1976.

WISNIAK, JAIME Jojoba oil and derivatives Oxford, Pergamon, 1977 52 p (Reprinted from *Progress in the Chemistry of Fats and other Lipids* 15 (3): 167-218 1977).

Esta es una revisión amplia del estado actual de los conocimientos sobre el aceite y derivados de la semilla de la jojoba *(Simmondsia chinensis)* Y es natural que el autor sea de Israel, pues este país es el que con mayor empeño está tratando de convertir a esta planta de los desiertos de México y Estados en un cultivo industrial (Cf *Turrialba* 24:340; 25:219).

Además de su interés como uso productivo de las tierras semiáridas, la jojoba ha despertado la atención de los conservacionistas por su potencialidad de reemplazar al cachalote y otros cetáceos en peligro de extinción como fuentes de esperma. La jojoba es una planta única porque sus nueces contienen un 50 por ciento de un aceite sin olor, practicamente incoloro, compuesto principalmente de monoesteres de cadena recta de los alcoholes y ácidos C 20 y C 22, con dos ligazones dobles La casi completa ausencia de glicerina indica que el aceite de la jojoba difiere radicalmente de todos los aceites procedentes de semilla; no es una grasa sino una cera líquida.

Antes de la llegada de los españoles, el aceite de jojoba era usado por los indios como fijador del cabello, uso principal que tiene todavía en México, único lugar en el que funciona una fábrica de cosméticos a base de jojoba en Guadalajara

Aunque las primeras páginas están dedicadas a la planta, su habitat, morfología, anatomía (con excelentes micrografías electrónicas de barredura), el principal énfasis es en el aceite, su composición, sus propiedades, su extracción La torta que queda después de la extracción se ha estudiado como alimento animal y se ha comprobado que su contenido de proteína varía entre 26 y 33 por ciento. Su contenido de lisina es bueno, pero el de metionina es pobre.

La parte más extensa es la correspondiente a la modificación química del aceite para obtener nuevos productos industriales Aunque el problema del cultivo comercial de la jojoba está en sus primeras etapas, ya se ve que se está aclarando el camino para el futuro, para cuando el aceite de jojoba se utilice como materia prima industrial Los estudios de modificación química del aceite incluyen a) polimerización *cis-trans* para solidificar el aceite o producir cremas; b) hidrogenación, que eleva el punto de fusión del producto y su estabilidad; c) sulfurización y sulfurclorinación para mejorar su empleo en las mezclas lubricantes, especialmente para máquinas que funcionan a altas temperaturas o presiones; d) epoxidación para obtener productos plastificadores y estabilizadores de plásticos a base de cloruro de vinil; e) maleinización, también para obtener plastificadores y suavizadores de caucho de nitrilo (Buna-N); y f) reducción de esteres, para la producción de alcoholes no saturados de cadenas largas.

Aunque no se puede decir que todas estas modificaciones químicas sean viables, uno debe expresar su deseo de que sólo tengan éxito aquellos usos en que el aceite de jojoba reemplace en la industria al aceite de cachalote; así contribuiría este producto a demorar la desaparición de un cetáceo valioso de este planeta.

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GREENLAND, D J y LAL, R, eds Soil conservation and management in the humid tropics London, Wiley 1977 283 p

Este volumen contiene los trabajos presentados en la Conferencia Internacional sobre Manejo y Conservación de Suelos en los Trópicos Húmedos realizada en Ibadán, Nigeria en junio de 1975

El texto está dividido en ocho secciones de las cuales, las primeras cuatro tratan sobre aspectos básicos en conservación de suelos y agua, caracterización de suelos y climas en relación al riesgo de erosión y manejo para controlar la erosión Las siguientes secciones cubren los sistemas de manejo y el riesgo de erosión en las regiones tropicales de Africa, Asia y América Latina, terminando con un capítulo sobre necesidades de investigación en control de erosión en zonas tropicales Se incluye un apéndice con las recomendaciones de la conferencia

Los editores hicieron un magnífico trabajo organizando el material del libro; la presentación es excelente y la acertada inclusión de capítulos teóricos al inicio permite comprender con facilidad el contenido de los últimos trabajos incluidos

Los 28 trabajos presentados cubren en detalle los fenómenos edáficos, climáticos y de manejo que afectan la conservación de suelos en los trópicos Se incluyen datos que complementan la información teórica presentada en textos de conservación de suelos y que por lo reciente, permiten al lector conscientizar la situación actual del problema No se incluye información sobre manejo de productos agroquímicos en suelos

El libro es recomendable para edafólogos, agrónomos y estudiantes de ciencias agrícolas como obra de consulta de alto valor Los profesores universitarios pueden hallar en él un magnífico libro de consulta, si no de texto, en cursos de manejo y conservación de suelos en los trópicos.

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